U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-257 585

Alaskan Industry Experience in Arctic Sewage Treatment

Environmental Protection Agency

May 71

PB 257 585

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No. Working Paper-13	2.	3. Recipient's Accession No. PB-257 585
4. Title and Subtitle Alaskan Industry Experience in Arctic Sewage Treatment.			5. Report Date May 1971 6.
7. Author(s) Sidney E. Clark, Amos J. Alter, J. W. Scribner, H. J. Coutts, and C. D. Christianson.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Environmental Protection Agency College, Alaska Alaska Water Laboratory			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address			13. Type of Report & Period Covered 14.

15. Supplementary Notes
Presented at the Purdue Industrial Waste Conference (26th), Held at Purdue University, Lafayette, Indiana, May 1971.

16. Abstracts

This report discusses the following:
Systems description; Waste characterization;
Discussion of systems performance.

17. Key Words and Document Analysis. 17a. Descriptors

*Sewage treatment
*Industrial waste treatment
*Alaska
Aeration
Construction
Pipelines
Oxidation
Lagoons(Ponds)
Incinerators
Sewage disposal
Performance evaluation
Biochemical oxygen demand
Arctic regions
North Slope
Prudhoe Bay

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 13B

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
National Technical Information Service Springfield, VA 22161	UNCLASSIFIED	32
	20. Security Class (This Page) UNCLASSIFIED	22. Price PC$4.00/ MF$2.25

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

ALASKAN INDUSTRY EXPERIENCE

IN

ARCTIC SEWAGE TREATMENT

by

Sidney E. Clark
Amos J. Alter
J. W. Scribner
H. J. Coutts
C. D. Christianson
W. T. McFall

Presented at
26th Purdue Industrial Waste Conference
Purdue University
Lafayette, Indiana
May 1971

Alaska Water Laboratory
Environmental Protection Agency
and
Alaska Department of Health and Welfare
State of Alaska
Fairbanks, Alaska

A Working Paper presents results of investigations which are to some extent limited or incomplete. Therefore, conclusions or recommendations--expressed or implied--are tentative.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
SYSTEMS DESCRIPTION	4
WASTE CHARACTERIZATION	12
DISCUSSION OF SYSTEMS PERFORMANCE	17
CONCLUSIONS	20
SELECTED REFERENCES	25

LIST OF FIGURES

		Page
Figure 1	Base Camp at Prudhoe Bay	2
Figure 2	Pipeline Road Construction Camp	2
Figure 3	Oil Exploration Camp	2
Figure 4	Alaska Pipeline Route	5
Figure 5	Aerial View of Pipeline Road Construction Camp	7
Figure 6	Physical-Chemical Treatment Plant at Pipeline Road Construction Camp	7
Figure 7	Physical-Chemical Treatment Plant	8
Figure 8	Surge Tank and Positive Displacement Pumps at Base Camp Sewage Treatment System	9
Figure 9	Extended Aeration System at Base Camp	9
Figure 10	Pasteurization-Incineration Modular System at Drill Camp	9
Figure 11	Interior of Pasteurization-Incineration System; Surge Tank and Sewage Metering Pump	11
Figure 12	Piping to Incinerator at Pasteurization-Incineration System	11
Figure 13	Permafrost and Pipeline Failure	13
Figure 14	Aerated Lagoon at Work Camp	13
Figure 15	Extended Package Plant at Drill Site	14
Figure 16	Base Camp Water Supply Flexible Line	14
Figure 17	Compressor House for Aerated Lagoon at Work Camp	14

LIST OF TABLES

		Page
Table 1	North Slope and Arctic Sector Pipeline Waste Water Treatment Facilities, March 1971	6
Table 2	North Slope Raw Sewage Characteristics	15
Table 3	Domestic Waste Disposal Methods	17
Table 4	North Slope Sewage Treatment Plant Effluent Characteristics	19
Table 5	Camp Water Usage	21
Table 6	Household Sewage Distribution	21
Table 7	Water Conservation Systems	23

ALASKAN INDUSTRY EXPERIENCE IN ARCTIC SEWAGE TREATMENT

INTRODUCTION

Alaska is America's last frontier and is a very large state. In fact, Alaska is as large as Texas, California, and Montana collectively with 586,400 square miles. Alaska has two-thirds of the United States' coastline or 33,904 miles of coastline and 40 percent of America's fresh water (1). The North Slope of the Brooks Range lying at the southern edge of Arctic Alaska, is a very harsh region having freezing conditions approximately 260 days of the year, and receives approximately five inches of precipitation each year. Lenses of dirty ice exist throughout the soil cover and mean annual ground temperatures at depths of 20 to 30 feet are near 15°F or lower (2). The environment of Alaska's North Slope is hostile to water supply and waste disposal practices common to southern Alaska, North and South Dakota, Montana, Wyoming, and Minnesota.

Camps on the North Slope must be thought of as isolated life support systems and therefore all of the aspects of public health must be considered for their impact, one on the others. Sewage disposal, solid waste disposal, and water supply are all parts of the same North Slope life support system, and solutions must be provided in a manner that prevents disease while simultaneously minimizing adverse effects on the environment. Several types of camps are utilized and Figures 1, 2, and 3 show three types. It should be obvious that solutions to utility problems will be different at each type of site.

The discovery of oil on Alaska's Arctic slope caused a tremendous scramble to define the extent of the find. Oil companies and their subcontractors soon found that Alaska intended to practice multiple use concepts in land management, thus requiring them to provide secondary waste treatment and, in many cases, complete treatment. The North Slope companies' systems range from simple stabilization ponds to tertiary treatment.

While all of the operations are unique by the nature of their North Slope location, two physical-chemical systems are of special interest. These advanced waste treatment systems are treating raw sewage from two mobile camps and are the only advanced waste treatment systems operating in the Arctic. A unique split system has recently been placed in operation at one drilling site. The system has an incinerator as its central core with all of the waste water except toilet flush water heat treated and chlorinated. The toilet flush water is burned in the incinerator. A variety of extended aeration package plants are in operation including facilities with long detention facultative polishing lagoons.

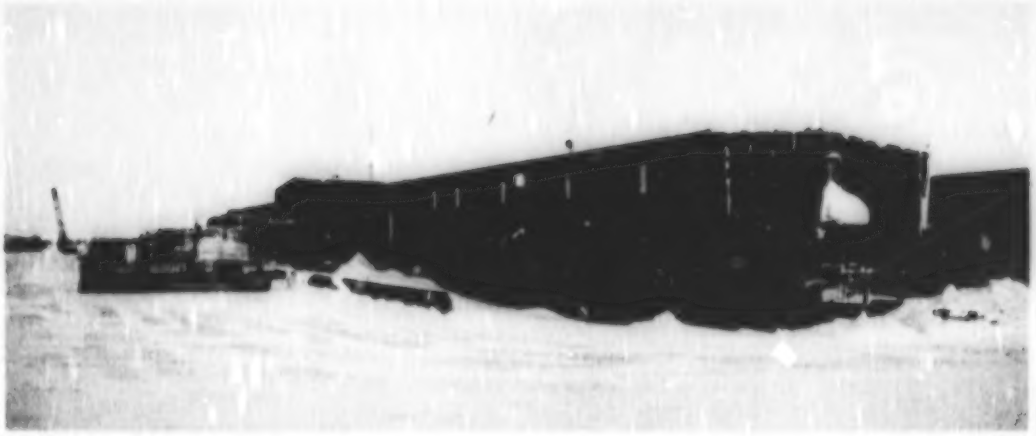

Figure 1 Base Camp at Prudhoe Bay

Figure 2 Pipeline Road Construction Camp

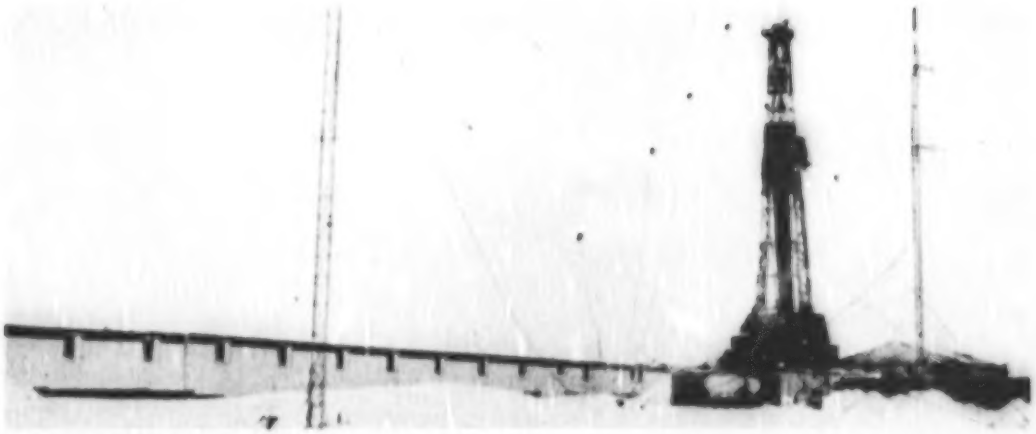

Figure 3 Oil Exploration Camp

Conservation of water and approaches for possible partial reuse become very interesting when one considers the cost of potable water. Estimates of $0.04 to $1.00 per gallon are common, depending upon site and availability of water. Considering a drilling site of 50 men where domestic water costs $0.40 per gallon (exclusive of treatment), toilet flushing water alone will cost $500 per day (1,250 gal/day) or $60,000 for a 120 day drilling operation (3).

In December 1969, there was only one operating plant (4), an aerated lagoon; however, in March 1971, there were 17 operating plants, an indication of the industry attitude once the ground-rules are defined.

SYSTEMS DESCRIPTION

A quick look at the location map of the North Slope and Arctic pipeline route, Figure 4, indicates the industry response to needs and requirements for adequate sewage treatment facilities for their construction, drilling, and base camps. There are still several cases where open disposal pits are being relied upon, but most of the permanent or semi-permanent camps have attempted to comply with State and Federal requirements. Several types of systems are represented, including physical-chemical, pasteurization-incineration, complete mix extended aeration, rated aeration, oxidation ditch extended aeration, and aerated lagoon. Table 1 tabulates plant type, size, location, fabrication, capacity, and discharge point.

Several of the extended aeration plants are followed by long detention lagoons, with the longest detention system being capable of storing the complete annual flow of the camp it serves at design capacity. An example of effluent lagooning from extended aeration is shown in Figure 5, North Slope Pipeline Construction Camp. The lagoon appears alongside and to the right of stacks of culverts.

The physical-chemical plants incorporate alum flocculation, upflow clarification, first stage downflow carbon adsorption-filtration, second stage upflow carbon adsorption, and chlorination with effluent storage for future reuse for toilet flushing. The physical-chemical plants are compact with the holding tanks taking up more space than the treatment units as illustrated in Figure 6, Physical-Chemical Waste Treatment. Figure 7 gives a better view of the plant. Note the use of a traveling belt paper filter for waste sludge conditioning.

With the exception of the oxidation ditches and the aerated lagoon, all systems are housed innheated structures. One of the more sophisticated extended aeration layouts is shown in Figures 8 and 9. Note the use of polyurethane insulation.

The North Slope sewage treatment plants because they are housed and heated are not really subjected to Arctic climatic problems, except humidity and air handling related to the associated housing that must be overcome.

The oxidation ditches are split culverts exposed to the environment. A very unique system, utilizing the pasteurization-incineration principles with the sewage split into "sewage" (toilet wastes) and "Waste" (Kitchen, laundry, and shower effluents) flows has been placed in operation at a drill site. The "sewage" is fed into a surge tank and metered into the incinerator burner. The burner system is currently being converted to an atomized approach. Primary clarification will be accomplished with a 100 micron vibratory screen. The metering pump and surge tank are

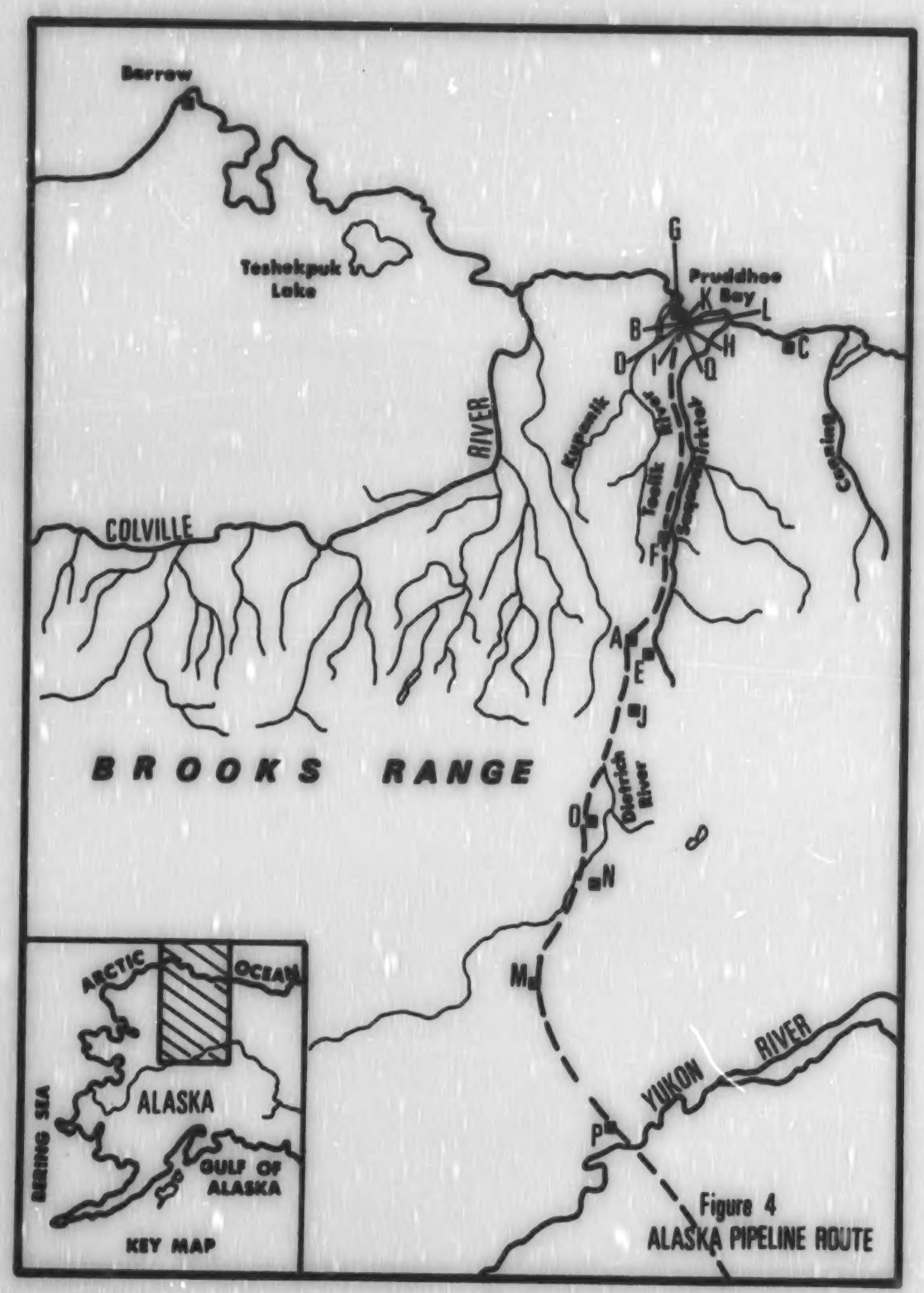

Figure 4
ALASKA PIPELINE ROUTE

TABLE 1

NORTH SLOPE AND ARCTIC SECTOR PIPELINE WASTE WATER TREATMENT FACILITIES, MARCH 1971

Activity	Location	Type	Mfr.	Construction	Unit Capac. GPD	Discharge	Design Pop.	Effluent Chlor.
Pipeline	Toolik	A Phys-Chem	I	Aluminum	24,000	Lined lagoon	340	yes
Oil Field	Deadhorse	B Phys-Chem	I	Aluminum	24,000	Lined lagoon	75	yes
Oil Field	Mikkelson	C Incineration	II	Steel	5,000	Tundra pond	50	yes
Oil Field	Deadhorse	D Ext. Aer.	III	Steel	2,500	Tundra pond	50	yes
Pipeline	Galbraith	E Ext. Aer.	III	Steel	19,000	Lagoon	320	yes
Pipeline	Happy Valley	F Ext. Aer.	III	Steel	24,000	Sagavanirktok	220	yes
Oil Field	Kuparuk	G Ext. Aer.	III	Steel	6,000	Kuparuk	60	yes
Oil Field	Deadhorse	H Ext. Aer.	III	Steel	5,000	Tundra	50	yes
Oil Field	Deadhorse	I Ext. Aer.	IV	Steel	7,000	Tundra pond	50	yes
Pipeline	Chandalar	J Ext. Aer.	IV	Steel	7,000	Chandalar	92	yes
Oil Field	Deadhorse	K Ext. Aer.	IV	Steel	8,333	Tundra pond	75	yes
Oil Field	Prudhoe	L Ext. Aer.	V	Steel	15,000	Tundra pond	200	yes
Pipeline	Prospect	M Ext. Aer.	VI	Pipe	18,000	Jim River	250	yes
Pipeline	Coldfoot	N Ext. Aer.	VI	Pipe	15,000	Koyukuk	190	yes
Pipeline	Dietrich	O Ext. Aer.	VI	Pipe	15,000	Dietrich	190	yes
Pipeline	5-Mile Camp	P Rated Aer.	VII	Steel	15,000	Surface	208	yes
Pipeline	Crazyhorse	Q Aer. Lagoon	VIII	Permafrost	15,000	Sagavanirktok	160	yes
Oilfield	Deadhorse	Pit		Permafrost		Tundra		no
Oilfield	Deadhorse	Pit		Permafrost		Tundra		no

Figure 5 Aerial View of Pipeline Road Construction Camp

Figure 6 Physical-Chemical Treatment Plant at Pipeline Road Construction Camp

Figure 7 Physical-Chemical Treatment Plant

Figure 8 Surge Tank and Positive Displacement Pumps at Base Camp Sewage Treatment System

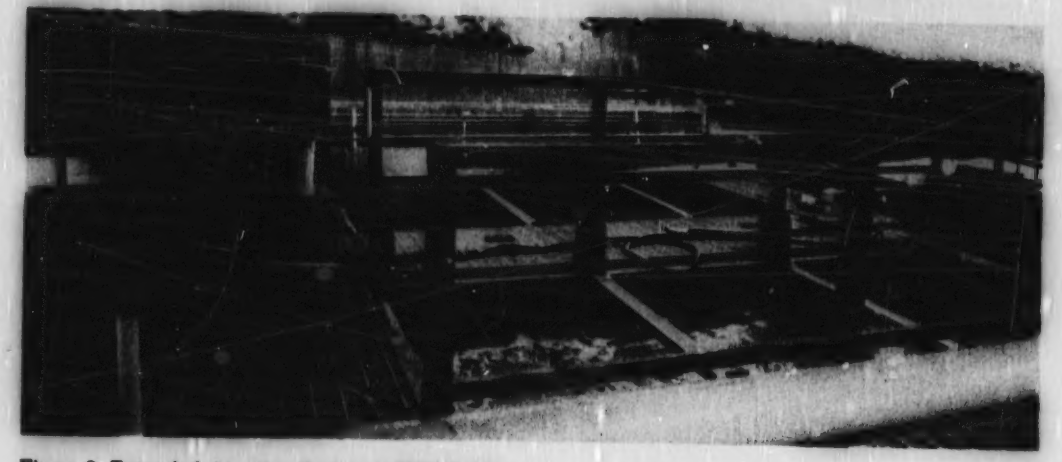

Figure 9 Extended Aeration System at Base Camp

Figure 10 Pasteurization-Incineration Modular System at Drill Camp

shown in Figure 11, and the metered flow goes into the incinerator through the uninsulated pipe shown in Figure 12. The total pasteurization-incineration module shown in Figure 10 also houses water treatment and storage. The "waste" waters are collected in the rectangular tank alongside the "sewage" surge tank shown in Figure 11, and are fed through a heat exchanger in the incinerator, with rate flow controlled by a thermostatically actuated valve.

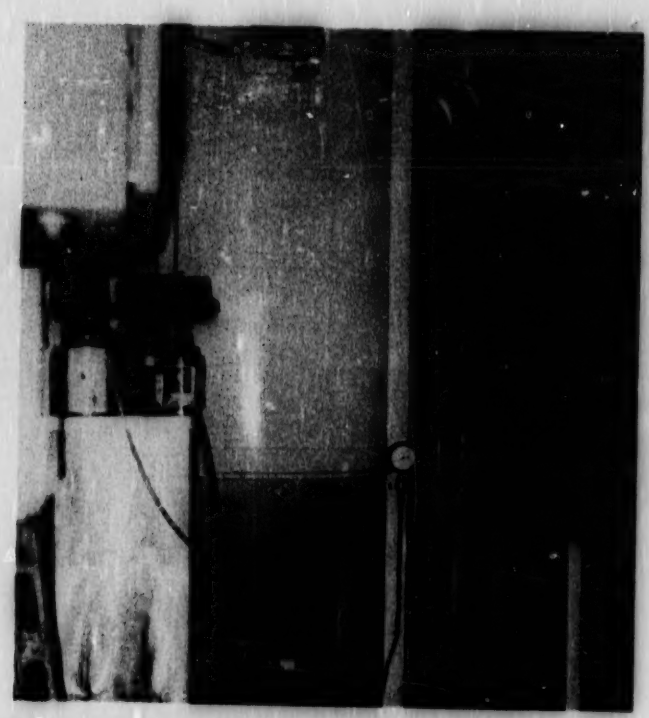

Figure 11 Interior of Pasteurization-Incineration System; Surge Tank and Sewage Metering Pump

Figure 12 Piping to Incinerator at Pasteurization-Incineration System

WASTE CHARACTERIZATION

The mode of life in North Slope camps varies from camp to camp according to the size of camp and the type of operation that it services; however, a basic trend exists. Camp life revolves around shift work with 10 or 12 hours per day shifts being dominant. Smaller camps will have sewage peak loads that are many times the average load. Larger camps, particularly those having central laundry facilities, including laundry service to satelite camps, will have a more evenly distributed load. Like any institutional sewage flow, North Slope camp flow tends to show very high peaks due to required activities.

Industry camps in remote locations have a history of providing excellent food in quantity and the men have a tendency to eat more. The Arctic places much greater demands on men. Therefore, one must assume that more BOD and COD per man finds its way into the waste streams. This, in fact, seems to be the case as is borne out in Table 2, North Slope Raw Sewage Characteristics. Sewage flows will vary from 30 gallons per capita per day to 130 gallons per capita per day depending upon the availability of water and weather conditions. When water is not severely short, due to weather conditions, trail conditions or mechanical failures, men of the North Slope camps use lots of water for warm-up showers, regardless of the cost of water per gallon.

Figures 13, Permafrost and Pipeline Failure, and 14, Aerated Lagoon, show the impact of heated sewage water on permafrost and demonstrate the results. The water from a sewer failure has created a large depression, indicating that the line was located over ice rich permafrost. Note the obvious embankment sloughing associated with the aerated lagoon. The aerated lagoon has a mild turbulance that assists in undermining the unstable ice rich permafrost that it is located in. The relatively warm aerated lagoon provides a heat source to promote thawing of underlying zones. These pictures should indicate the reasons for excluding lagoons from ice-rich permafrost areas. Arctic facultative lagoons are nothing more than storage lagoons, and are therefore eliminated for that reason. If allowed, what about future public health? Figure 15 shows a preferable means of providing sewage treatment while protecting the permafrost. Figure 15 also illustrates why sewage treatment is extremely expensive on the North Slope. Building utilidors and insulating and heating the isolated plant and individual sewerlines is very costly in terms of construction materials and maintenance and operating labor. Figure 16 shows a successful means for providing flexibility and environmental protection for pressure lines. The one shown happens to be a water line but the same approach is feasible for pressure sewer lines.

The use of wood structures to protect equipment appears to present an unnecessary fire hazard, particularly if equipment is in a small space such as shown in Figure 17.

Figure 13 Permafrost and Pipeline Failure

Figure 14 Aerated Lagoon at Work Camp

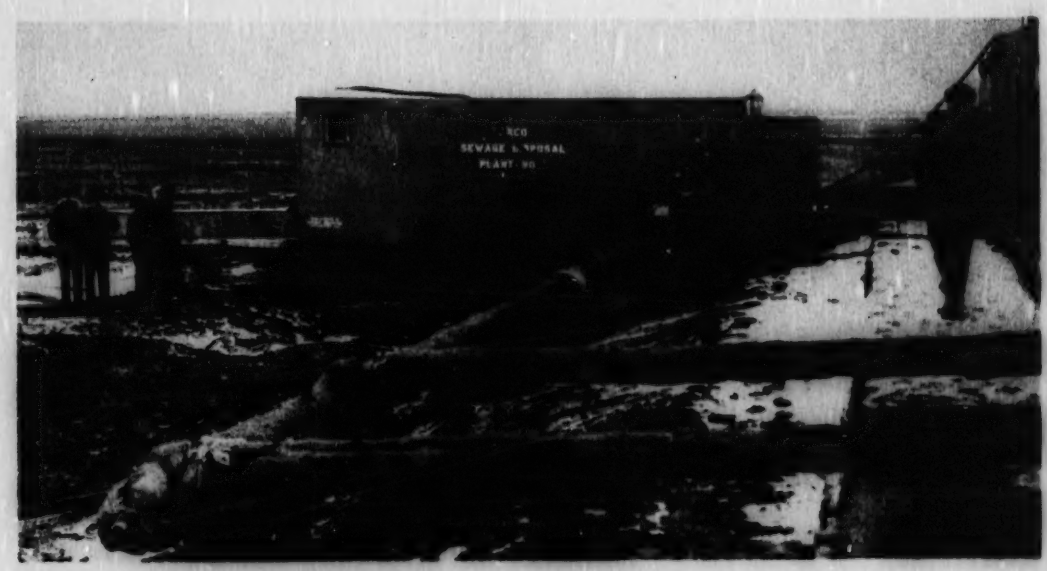

Figure 15 Extended Package Plant at Drill Site

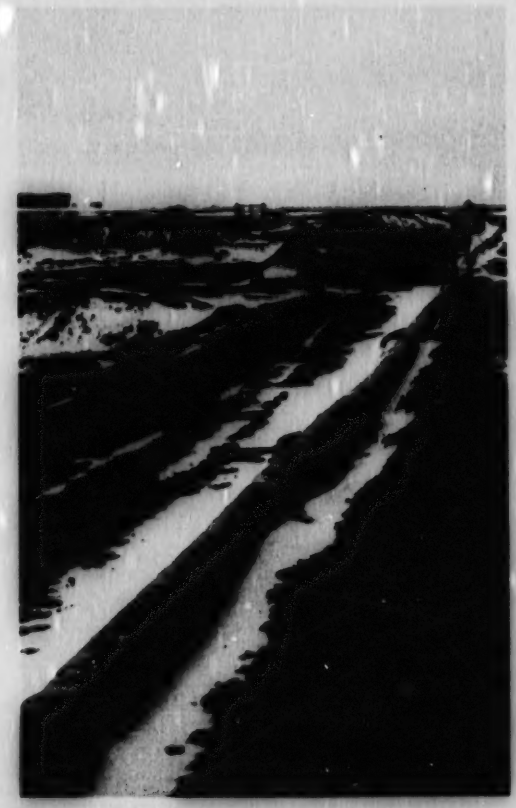

Figure 16 Base Camp Water Supply Flexible Line

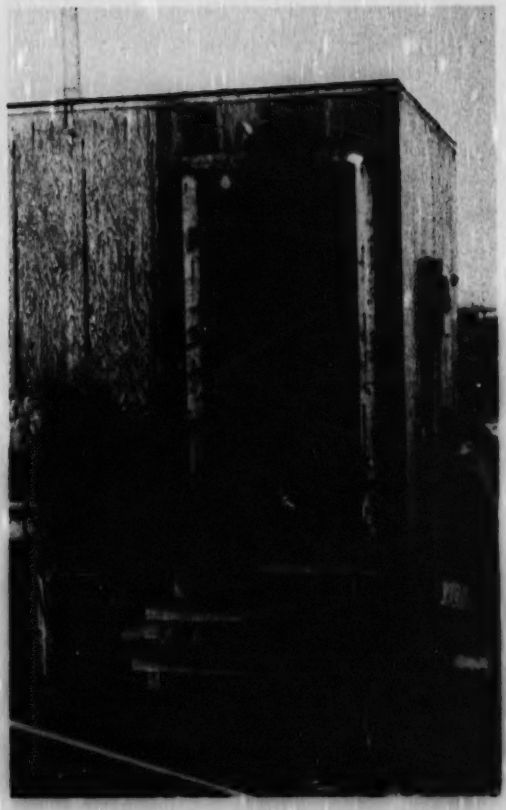

Figure 17 Compressor House for Aerated Lagoon at Work Camp

TABLE 2

NORTH SLOPE RAW SEWAGE CHARACTERISTICS

Location	Date	Population	BOD	COD	TS	SS
A	7/16/70*	12	484	842	894	387
	8/20/70*	12	380	2440	2790	330
	9/30/70*	9	-	1605	1298	228
	3/17/71*	7	-	7610	-	-
	3/22/71*	7	-	3260	-	-
B	8/20/70*	10	740	2000	2024	816
	9/16/70*	6	-	842	-	811
C (All wastes except toilet)	4/13/71**	50	-	550	-	-
C (Toilet wastes)	4/21/71	50	-	460[1]	-	-
E	7/16/70*	15	500-1100	3600	3316	2788
	9/30/70*	10	-	232	582	256
L	8/20/70*	85	7330	2510	3154	1547
(Average of 7 days of composites in March 1971)**		75	600	1150	-	1500

*Grab samples from mixed surge tanks

**Composite samples taken with composite sampler on basis of frequency but not flow matching

[1]Sampled by others

The extended aeration plant at site D serves a drilling operation and is, therefore, subjected to start-up conditions several times per year and variations in flow. During the past winter, start-up was slow and a biological mass had not developed after three months of operation. The reasons for this slow start-up are not clear, but probably can be attributed to hydraulic overloading, as well as a normal lag period.

DISCUSSION OF SYSTEMS PERFORMANCE

Placing sewage treatment systems in operation on the North Slope of Alaska is not an easy task. Yet, several companies within less than one year responded to State requirements (Alaska Environmental Health Practices) in an admirable way as can be seen by comparison of Table 1, North Slope and Arctic Sector Pipeline Waste Treatment Facilities, March 1971, and Table 3, Domestic Waste Disposal Methods, December 1969. Several different types of sewage treatment plants found their way to the North Slope and a discussion of their performance is worth while.

TABLE 3

Domestic Waste Disposal Methods*

		Number used	Remarks
Man-made ponds:	Direct to ponds	28	One aerated
	From recirculating toilets	3	
	From septic pit	1	
		32	
Burial methods:	Outhouses	4	One on tundra
	Dry collection (barrels, bags and chemical toilets)	4	with no pit
	Recirculating toilets (effluent buried)	1	
		9	
Package plant		1	Not operable yet, being installed
		1	
		42**	

*Reference 4

**One geophysical camp used lagoons for wastes from chemical toilets plus an outhouse.

The effluent quality on specific dates for a number of the plants is listed in Table 4. As can be seen from Table 4, the plant effluents still have a considerable load of BOD, COD, and suspended solids. Assigning usual removal percentages is not an easy task with these plants, as the basic strengths of raw waste needs better definition. When looking at Table 2, what do you use for raw BOD--330, or 1100, or an average of 590? For raw COD--232 or 7610, or an average of 2085? Although the results are not indicative, the physical-chemical plants produced very clear effluents. Visual examination of samples showed a much clearer effluent from them than from the biological plants. One of the two physical-chemical plants was utilized by Kreissl for studies conducted at Cincinnati and his results are reported in a paper presented at the Cold Regions Engineering Symposium, August 17-19, 1970 (5). In that report, he stated that the mean effluent COD for the unit was 13.5 mg/l, and the total hydrolyzable phosphorus in the final effluent was equal to less than 0.1 mg/l as P during 50 percent of the runs. Kreissl, et al., states, "It is significant to note that the effluent color levels were below the U. S. Public Health Service Drinking Water Standards, maximum of 15 units during 90 percent of the runs. A recent recommend - tion for a toilet flushing standard of 30 units of color was never exceeded during the testing period. The turbidity of the product water was below one J. U. during most of the runs. In terms of requirements, the product quality was below the USPHS standards for drinking water, 5 J. U. during approximately 85 percent of the test runs and below the suggested limit for toilet flushing water, 20 J. U. 100 percent of the time."

While the physical-chemical plants outperformed biological plants, one must ask why they did not perform as well as the one unit did when tested in Cincinnati. Several potential reasons exist: (1) The raw wastes are stronger; (2) The raw water chemical make-up is significantly different; (3) The plants operated at less than 10 percent of design capacity and, therefore, were not operated for long periods of time; (4) Untrained operators; and (5) Infrequent carbon backwash and allowing the pin floc to accelerate the carbon aging. The contractor has noted that the belt paper filter utilizes an excessive amount of paper, thus, creating an extremely expensive operation when the raw sewage is pre-filtered through it. When paper filtering was only applied to the sludge dewatering, the paper utilization decreased tremendously, but sedimentation problems were created with the flat bottom feed surge tank, because the solids originally taken out of the raw sewage by the paper filter were now going into the tank to settle out.

The biological treatment plant at Site E is operated by the camp manager because he has taken a special interest in the system. He has augmented the feed with kitchen scraps and fish wastes to increase the organic feed concentration, thus compensating for the fact that the camp has run at less than 10 percent of capacity most of the time. Table 4 shows the results of this conscientious operator when compared to other extended aeration plants. However, this is the exception, not the rule.

The authors have observed that biological plants placed in operation to serve drill sites really are not much more than primary settling basins for the first two months.

TABLE 4

NORTH SLOPE SEWAGE TREATMENT PLANT EFFLUENT CHARACTERISTICS

System	Date	BOD	COD	SS
A	7/16/70	78	160	69
	8/20/70	46	221	111
	9/16/70	-	318	16
	9/30/70	-	309	11
	3/17/71	-	373	25
B	8/20/70	329	435	61
D	9/16/70	-	696	291
E	7/16/70	33	-	68
	9/01/70	28	-	15
	9/30/70	-	113	28
F	9/30/70	0	324	147
L	7/30/70	180	364	34
	(1)	10	49	10
	8/20/70	153	371	106
	(1)	15	106	22
	9/16/70	-	1167	1049
	(1)	-	357	388
	3/12/71	40	170	68
Q	9/16/70	-	268	148

(1) Sample at end of long detention lagoon

CONCLUSIONS

The first major conclusion that one should draw is that the oil industry responded in a major way to the need for adequate sewage treatment in Arctic Alaska and did so in a relatively short period of time.

Camp water usage varies widely, depending upon the camp. If water becomes extremely short because of weather or other conditions, the water usage will drop to approximately 30 grams per capita day (gpcd) as a direct result of curtailment of shower and laundry activity. These drops in water use are unplanned and create extremely uncomfortable conditions for the men. If a camp operator has the means for providing an adequate water supply, a usage rate greater than 50 gpcd should be expected. The cost of providing water does not bother North Slope workers; it's just one of management's problems. Table 5 lists water usages as reported by North Slope operators.

North Slope sewage strength is going to be greater than suburban temperate region sewage, with BOD strengths of 400 to 800 mg/l and COD strengths of 1000 to 1600 to be expected. As was pointed out in the paragraph above, the flows are not dramatically less.

Biological plants can operate on the North Slope and provide a high level of BOD and solids removal, in fact, several systems are operated efficiently. Just like extended aeration plants elsewhere, many of the well protected plants of the North Slope do not receive the qualified operator attention that is necessary to assure continuously high levels of removal; consequently, they do not provide the levels of treatment expected of them in terms of BOD and COD removal but this may be due in part to the strength of influent sewage. All of the operators have designed their extended aeration plants to rely on a "lagoon" to trap the "waste" solids instead of providing intentional sludge wasting and disposal. Biological plants do not require a supply of chemicals; therefore, operating costs should be less than for physical-chemical plants. The first costs of equipment and on-site preparation are not greatly different for physical-chemical and biological systems, except when a long detention lagoon is required behind an extended aeration system. In the latter case, the first cost of an extended aeration lagoon system can go out of sight when compared to a physical-chemical treatment system. Extended aeration systems that are set up to serve drill sites or other types of camps that are going to be on location for 120 days or less do not actually reach optimum operating conditions before the job is one-half to two-thirds completed, and in some cases, completed. The effluent from an extended aeration system that is not operating efficiently and is turbid will not be properly disinfected. If high levels of secondary treatment are required at a drill site, and no special extended aeration system start-up procedures are followed, the first 6 to 10 weeks are nothing more than an "unintentional" white-wash job.

TABLE 5

CAMP WATER USAGE

Camp	Gallons Per Capita Per Day (3)
A	100 to 120
C	32 to 80
D	70 to 100
E	50 to 100
F	50
L	100 to 120

Average = 83.8

TABLE 6

HOUSEHOLD SEWAGE DISTRIBUTION
[After Bailey, et al. (6)]

Waste Source	Volume of Waste (gpcd)				
Total Flow	30	40	50	75	100
Kitchen	0	7	10	10	15
Toilet	15	15	20	25	30
Showers, wash basins	15	18	20	25	35
Laundry	0	0	0	15	20

The physical-chemical plants did a reasonable job and provided a clear effluent most of the time. Like some of the biological plants, these plants were designed to handle much larger waste loads than were actually handled during the past year. The plants did not perform as expected, or as one of them had under prior tests. The probable reasons for the efficiency reduction are several, including long periods of shut-down between periods of use, infrequent activated carbon backwashing, and untrained operators. The physical-chemical plant does not require a start-up period and, therefore, produces a quality effluent that can be effectively disinfected immediately after camp start-up; not 6 to 10 weeks later. At the end of an operation, the physical-chemical plant can be drained, the sludge dewatered and burned, and the activated carbon removed and burned.

Actually, all the sewage treatment plants on the North Slope are transplants and in fact, misfits. North Slope camps are isolated life support systems. Newly designed camps are desperately needed that treat the whole camp and all of its functions as an integrated system, thus recognizing the interdependence of human comfort, group hygiene, basic services provision, water supply, sewage treatment, solid waste management, and air pollution control. Preconceived notions that particular types of equipment, plumbing, etc., are unacceptable because they are unconventional or because they are considered to be a luxury, should not be allowed to bias the new design. Oh yes, the old standard excuse provides an easy out - "Plumbing codes will stop any changes, after all, they can never be changed." However, its amazing how new approaches can become acceptable if they are proven superior and do not threaten any block of jobs within the jurisdiction involved.

Starting with the interrelationship of water supply, water use fixtures, human comfort and architecture use, requirements can be reduced dramatically. Let's look at some examples. Tables 5 and 6 give temperate climate household water usage figures and North Slope water usage figures. Table 7 shows an analysis of estimated water supply savings based on utilization of available hardware that actually would provide a more comfortable camp. If the changes were pushed only to the limits of available "conventional" hardware and techniques, the savings in water use could be 41 gallons per person per day or approximately 2050 gallons per day for a 50 man camp. If the water has a true value of 35 cents per gallon, as one operator has estimated, the 2050 gallon savings turns into $717.50 per day or $71,750 for a 100 day operation. Going along with some "unconventional" approaches, the usage of water can be reduced approximately 55 gallons per man per day without sacrificing any comfort or convenience. That additional 14 gallons per man per day would represent a total of 700 gallons per day for the 50 man camp example or $245 per day and $24,500 for the 100 day operation. The unconventional elements of the system consist of either utilizing vacuum flush systems such as have been utilized in Europe for many years, or utilization of treated shower water as a flushing water for conventional

TABLE 7

WATER CONSERVATION SYSTEMS
(useage in gallons per capita per day)

	Conventional Systems					Unconventional Systems			
System	1	2	3	4	5	6	7	8	9
Kitchen*	7.00	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75
Laundry*	8.75	8.75	8.75	8.75	8.75	4.50	4.50	4.50	4.50
Utility*	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Bath**	40.00	40.00	30.00	30.00	30.00	30.00	30.00	30.00	15.00
Lavatory*	2.25	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Toilet*	25.00	25.00	25.00	17.50	13.50	13.50	2.50	0	0
TOTAL	84.25	83.75	73.75	66.25	62.25	58.00	47.00	44.50	29.50
Water Savings Over 1	-	0.50	10.00	18.00	22.00	26.25	37.25	39.75	54.75

System Description

System	1	2	3	4	5	6	7	8	9
1. Conventional Plumbing	X	X	X	X	X	X	X	X	X
2. Replace Faucets w/Aerator Faucets		X	X	X	X	X	X	X	X
3. Replace Shower Heads w/Flow Control Heads			X	X	X	X	X	X	X
4. Replace Water Closet w/Shallow Trap Closet				X					
5. Replace Water Closet w/Flush Valve Toilets and Urinals					X	X			
6. Replace Top Load Washers w/Front Load Machines						X	X	X	X
7. Replace Water Closet w/Vacuum Flush System							X	X	X
8. Add Physical-Chemical Treatment of Shower Water and Recycle for Toilet Flush								X	X
9. Add Sauna for Warm-up Instead of Shower Warm-up									X

*Figures from Bailey (6)
**Figures adjusted to reflect North Slope averages

toilets. Use of a vacuum sewage transmission system opens up new avenues of physical-chemical sewage treatment with a dual collection system providing for separation of the strong and weak streams. Handling sewage solids should be considered in conjunction with solid waste management, and incineration is presently the preferred means for disposal. The example presented above has been offered to demonstrate how economics, occupant comfort, and environmental quality control may be combined.

SELECTED REFERENCES

1. Anonymous, The Alaska Plan, A Statement of Economic and Ecological Purpose, Alaska Department of Economic Development, Pouch EE, Juneau, Alaska 99801.

2. Alter, Amos J., Sidney E. Clark, E. K. Day, J. M. Cohen, and James F. Kriessl, "Arctic Waste Management," presented at the 25th Purdue Industrial Wastes Conference, Purdue University, West Lafayette, Indiana, May 1970.

3. Conversations and interviews with North Slope operators.

4. Scribner, Jonathan W., Elroy K. Day, Warren T. McFall, and Leroy Reid, "Report of Survey, The Influence of Oil Exploration and Development on Environmental Health and Quality on the Alaskan North Slope," Alaska Department of Health and Welfare, Federal Water Pollution Control Administration, Arctic Health Research Center, December 1969.

5. Kreissl, J. F., S. E. Clark, J. M. Cohen, and A. J. Alter,"Advanced Waste Treatment and Alaska's North Slope," presented at Cold Regions Engineering Symposium, 21st Alaska Science Conference, University of Alaska, College, Alaska, August 17-19, 1970.

6. Bailey, James R., Richard J. Benoit, John L. Dodson, James M. Robb, and Harold Wallman. "A Study of Flow Reduction and Treatment of Waste Water from Households," Contract No. 14-12-428 between the Federal Water Pollution Control Administration and General Dynamics, Electric Boat Division, U. S. Department of the Interior, Federal Water Pollution Control Administration, Cincinnati, Ohio.